September 17, 2009

VIA ELECTRONIC COMMENT FILING SYSTEM (ECFS)

Ms. Marlene H. Dortch
Office of the Secretary
Federal Communications Commission
445 12th Street SW
Washington, D.C. 20554

Re: Ex Parte Communication, 47 C.F.R. § 1.1206
***In re National Broadband Plan for Our Future*, GN 09-51**

Dear Ms. Dortch:

On September 16, 2009, Andrew Afflerbach of CTC, Joanne Hovis, Nick Miller of Miller & Van Eaton, P.L.L.C. and I, on behalf of the National Association of Telecommunications Officers and Advisors, along with Jack Belcher on behalf of Arlington County, Virginia; and Mitsuko Herrera on behalf of Montgomery County, Maryland met with Robert Curtis, Tom Koutsky, BJ Neal, Kevin King, and Mukul Chawla of the Federal Communications Commission. The purpose of the meeting was to discuss the need for municipal participation in the National Broadband Plan. Specifically, the meeting discussed the role of local government self-provisioned networks in broadband deployment. We spoke from the attached document.

Pursuant to Commission rules, please include a copy of this notice in the record for the proceeding noted above.

Sincerely,
/s/ Matthew R. Johnson
Matthew R. Johnson
Legal Fellow
NATOA

cc: Robert Curtis
Tom Koutsky
BJ Neal
Kevin King
Mukul Chawla

Local Government Self-Provisioned Networks:

A Game Changer in Local Broadband Deployment

September 16, 2009

Overview

- Local government networks: Big Broadband to anchor institutions
- How we use the networks
- Compelling economics if supportive federal policy
- Lessons learned

Why Do They Work?

- The best current example for the FCC
  - Captures the broadband deployment externalities
  - Benefits the entire community
  - Middle mile capacity and nodes for last mile commercial services
- Compelling Economics
  - Low cost network elements
  - Scaled to the user community's demands
  - Aggregated user requirements
  - Controls on major network cost drivers
    - Real estate
    - Tower sites
    - ROW access
    - Anchor institution building access

Why Do They Work?

- Transparent, Open, User Defined Networks, Incremental Cost Pricing
  - Address Anchor Institutions
    - Public Safety
    - Public Health Clinics and Hospitals
    - Traffic Management
    - Social Services Data Management
    - E-Government
    - Education
    - Large Property and Tax Data Base Management
  - The logical neighborhood node for commercial broadband services to underserved areas

Current Status

- Typically open platform for new applications
- Middle mile connection points for alternative last mile systems
- Price ceilings on dominant provider charges
- Extending Internet(2) and National Lambda Rail capabilities to anchor institutions

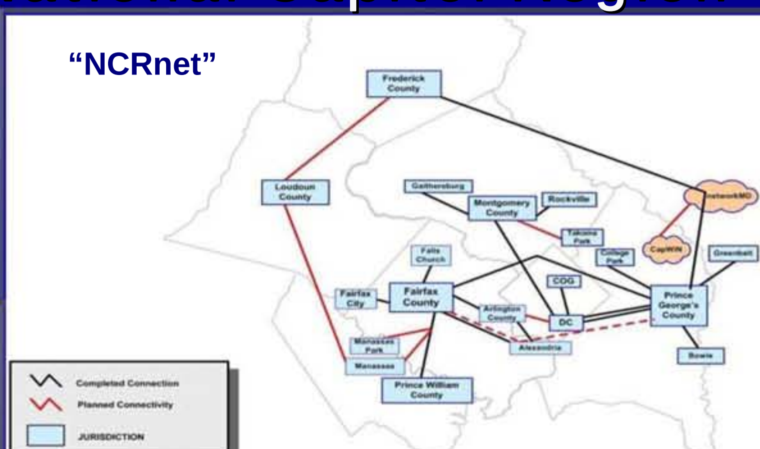
Almost There…

- Numerous self-provisioned local government networks connecting anchor institutions
- With appropriate federal policies, they can become ubiquitous
- Vary in organization
- Exist in parallel with commercial networks

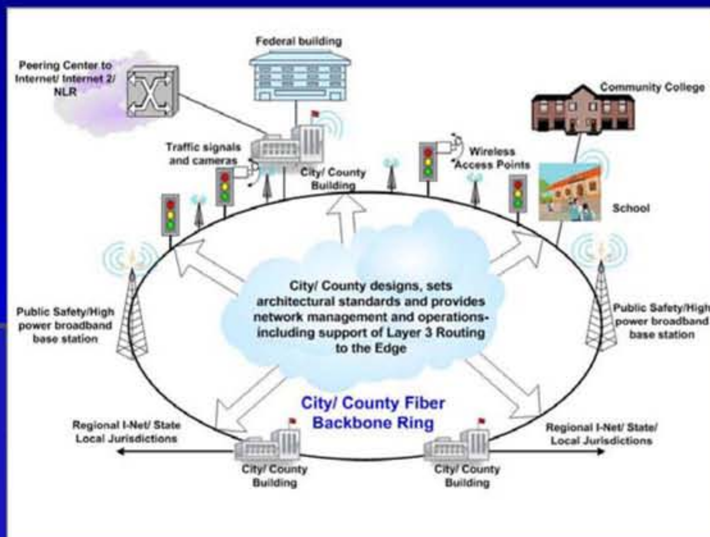
How Did They Develop?

- Through a combination of government policies and changing economics
  - Capacity set-asides
    - Cable franchising
    - ROW franchising of CLECS
  - Aggregated demand
  - Bigger bandwidth requirements than incumbents offered
  - Lower cost (and higher functionality) alternative to incumbent prices

National Capitol Region



Critical public safety needs



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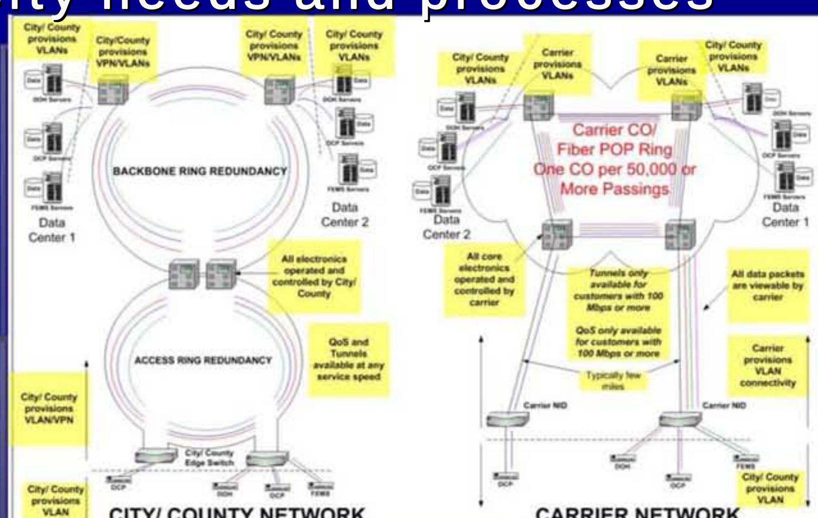
Case study: New York City I-Net

- Fully redundant SONET backbone ring
- Remained operational on 9/11, even as carrier networks failed, despite loss of connectivity to hub site

Drawbacks of traditional leased services

- Architecture not transparent
  - Redundant physical connectivity almost never provided end-to-end
  - Difficult to assess vulnerabilities from damage or security risks to backbone plant and equipment
- Maintenance and reliability driven by broader business considerations
- Capacity provided on a shared-basis
  - Non-critical communications may not be prioritized in a crisis situation
- Sensitive communications may not be sufficiently secure
- Backbone equipment redundancy
- Quality and capacity of backup electrical power

City network customized for city needs and processes



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One Maryland Broadband

- Cost-effective broadband (100 mbps to 10 gbps) to community anchor institutions
- Interconnected public safety & continuity of operations applications
- Public-private broadband deployment partnership opportunities

Internet Subscribership-Related Demographics

Montgomery Co. FiberNet

289 Sites & Counting

•Gov't Bldgs

•Police & Fire Sta.

•EOC & PS Radio

•Schools & Colleges

•Libraries

•Employment Ctrs

•Community, Youth, and Senior Centers

•Public Housing

•Transit Centers

MC Fibernet Capacity

- White: FiberNet I = 6.9 Gigabits/sec
- Turquoise: FiberNet 100 Mbps to Each School
- Blue: FiberNet II = 455 Gigabits/sec
- Red: FiberNet III = 1.04 Terabits/sec

Current Broadband Service Levels

- T-1 Elementary Schools
  - 1.544 Mbps bi-directional bandwidth
  - $3,652 per Mbps per site annual operating costs
  - $1,826 per Mbps per site with e-rate discount
- FiberNet Elementary Schools
  - 100 Mbps bi-directional bandwidth
  - <$71.11 per Mbps per site annual aperating costs*
    - *Cost includes voice and video operating costs
    - 1 Gbps future capacity or <$7.11 per Mbps per site
    - *Per site cost reduced as additional sites are added

Strategic Operation Cost Comparison

- T-1 Service: 1.544 Mbps dedicated bandwidth capacity
  - $597,840 annual operating costs
  - $298,920 with e-rate discount
- Cable Modem: 16 Mbps down/4 Mbps up shared bandwidth
  - $159,000 annual operating costs
- Wireless: 50 Mbps shared bandwidth
  - $500,000—$700,000 annual operating costs
- FiberNet: 100 Mbps dedicated bandwidth capacity
  - Net zero direct additional annual operating costs
    - Incremental use of existing operating resources
  - Only option with future capacity to support media-rich future applications

Why Self-Provisioning?

- Benefits:
  - Speed/Bandwidth
  - Security/Redundancy/Remote Monitoring & Support
  - Cost-Effective Service
    - $7 to $70 per mbps v. $1800 e-Rate T-1
- Enables:
  - VOIP Telephony & Video Conferencing
  - Video Streaming
  - Secure Intra/Inter-Agency Communications (including State & Federal) and Database Access
  - Continuity of Operations/Disaster Recovery

Lessons Learned

- Local government middle mile/anchor networks have compelling economics
  - Low cost to construct and operate fiber
  - Incremental cost construction opportunities
  - Reduced operating costs
  - Dramatic savings over carrier offerings

Lessons Learned

- Compelling economics are NOT sufficient
  - Government and non-profit budgets often cannot finance construction
  - Dominant provider opposition
  - Regulations and statutes preclude efficient economics
- Several mechanisms could reduce and share network construction and operation costs
  - Enable local government networking to address middle mile and anchor needs and reduce commercial last mile build costs
  - Address anti-competitive restraints on government operations and financing
  - Use ROW management and access to ensure carrier cooperation and capacity set-asides
  - Use spectrum more efficiently

Lessons Learned

- Expect significant resistance from dominant carriers
  - Carriers like large, captive users of expensive dominant carrier services
  - Local government networks break down incumbent market power and monopoly pricing
  - Dominant carriers want to foreclose or burden local government networks

Questions?

- We welcome any additional questions or comments you may have.
- Contact Information:
  - Joanne Hovis, hovis@natoa.org
  - Andrew Afflerbach, aafflerbach@ctcnet.us
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  - Nick Miller, nmiller@millervaneaton.com

Sample List of Community I-Nets*†

Albuquerque, NM
Alexandria, VA
Ann Arbor, MI
Annapolis, MD
Anne Arundel County, MD
Arcata, CA
Arlington County, VA
Arvada, CO
Atlanta , GA
Aurora, IL
Austin, TX
Beaverton, OR
Bellevue, WA
Beverly Hills, CA
Blaine, MN
Bloomfield Hills, MI
Bloomington, MN
Boston, MA
Bowie, MD
Brooklyn Park, MN
Brunswick, ME
Carroll County, MD
Castle Rock, CO
Champlin, MN
Charlotte, NC
Cincinnati, OH
Corvallis, OR
Cottage Grove, MN
Covington, KY
Dallas, TX
Dearborn, MI
Denver, CO
Dubuque, IA
Durango, CO
Englewood, CO
Enumclaw, WA
Eureka, CA
Fairfax, VA
Federal Way, WA
Fort Lauderdale, FL
Foster City, CA
Frederick County, MD
Fremont, CA
Fridley, MN
Geneva, IL
Gold Beach, OR
Greensboro, NC
Greenwood Village, CO
Haverhill, MA
Hoffman Estates, IL
Honolulu, HI
Indianapolis, IN
Inver Grove Heights, MN
La Plata, MD
Lakewood, CO
Lakewood, WA
Largo, MD
Leesburg, VA
Littleton, CO
Los Angeles, CA
Longmont, CO
Loudoun County, VA
Monterey, CA
Montgomery County, MD
Murfreesboro, TN
Nevada City, CA
New York, NY
Northbrook, IL
Oregon City, OR
Palm Beach, FL
Palm Desert, CA
Palo Alto, CA
Pasadena, CA
Philadelphia, PA
Portland, OR
Prince George's County, MD
Prince William County, VA
Redding, CA
Redondo Beach, CA
Renton, WA
Rialto, CA
Richardson, TX
Richland, WA
Richmond, CA
Richmond, VA
Rockville, MD
Roseville, MN
Sacramento, CA
Salem, OR
Salinas, CA
Salisbury, NC
San Francisco, CA
San Rafael, CA
Santa Barbara, CA
Santa Monica, CA
Sarasota, FL
Schaumburg, IL
Seattle, WA
Shakopee, MN
Sioux Falls, SD
Skokie, IL
Smyrna, TN
South Portland, ME
Southfield, MI
St. Louis Park, MN
St. Louis, MO
St. Paul, MN
Stuart, FL
Surprise, AZ
Tacoma, WA
Takoma Park, MD
Tampa, FL
Torrance, CA
Tucson, AZ
Tulsa, OK
Vancouver, WA
Ventura, CA
Washington, DC
Waterford, MI
Westminster, MD
West Allis, WI
West Bloomfield, MI
Williamsburg, VA
White Bear Lake, MN
Wilmington, MA
Winston-Salem, NC
Woodbridge, VA
Yuma, AZ

* I-Net stands for Institutional Network and is defined as "a communication network which is constructed or operated by the cable operator and which is generally available only to subscribers who are not residential subscribers." 47 U.S.C. § 532(f).

† This is only a small sample of communities with self-provisioned networks. Only NATOA member communities with cable franchise related networks (I-Nets) are listed.

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Brief Engineering Assessment: Cost estimate for building fiber optics to key anchor institutions

Prepared for the Schools, Health, and Libraries Coalition
September 2009

Columbia Telecommunications Corporation • 10613 Concord Street • Kensington, MD 20895
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1. Introduction

The following is a brief engineering assessment of the cost of building fiber optics to America's key anchor institutions: schools, health care facilities, and libraries.

The cost and completion time of large-scale fiber optic deployments depend on a wide range of factors, including overall program management, access to the public right-of-way, the quality and quantity of available labor, coordination between the builder and the entities being connected, supply of materials, and the integration of the physical and electronic portions. Successfully operating a fiber network also requires effective governance, a business model, and qualified entities performing maintenance, moves, adds, and changes.

Good planning practices can reduce the risk inherent in large-scale infrastructure projects and help the project owners complete the project cost-effectively and in a way that best suits the people to be connected and served. This document 1) outlines strategies for network deployment, 2) briefly illustrates key cost factors, and 3) provides case studies and approximate deployment costs.

2. Network Costs

Averaged over a large sample size, it is probably suitable to estimate $50,000 as a national goal for per-site construction cost of large networks serving community anchors such as schools, libraries, and government facilities. As this report suggests, the designers of the network should seek opportunities to take advantage of existing fiber and other infrastructure.

However, this cost would be limited to areas where sufficient density (i.e., sites per fiber mile) exists—*urban, suburban, or small town areas where two or more sites, on average, can be reached per mile of fiber.* It would also assume the existence of a national or regional backbone to interconnect the various resulting fiber "islands" (many of which are not currently fiber-connected by any carrier) to provide true fiber speed universally.

Finally, this cost is for a minimum level of "transport-only" networking. In order for a new community anchor network to provide added value over incumbent networks, it is worth analyzing the level of redundancy, network management, and other value-added features that community anchor users require. Depending on the level of network intelligence required, the additional cost may average an additional $25,000 to $50,000 per site.

3. Strategies to Control Construction Costs

A number of strategies have been found to effectively reduce the cost of a network deployment and increase the likelihood of success:

1) Maximize economies of scale
2) Be flexible in choosing specific technical solutions
3) Coordinate network intelligence with users' needs

Maximize Economies of Scale

Constructing a network requires coordinating many moving parts—everything from determining the needs and vision, creating a design, and acquiring funds, to facilitating procurement, selecting contractors, obtaining right-of-way access, preparing the right-of-way, obtaining permits, performing construction, performing restoration, overseeing the work, testing the network, and activating users.

Constructing fiber also requires coordination with entities that are indifferent to or opposed to the network—for example, incumbent telecommunication companies, power providers, and utility companies that control utility poles and conduit and are potential competitors. Those companies may require a new network provider to pay—not only to create space for its fiber optics, but to optimally relocate other utilities on the poles or create other "improvements" in a process known as "make-ready," which may lead to high cost and delay.

Construction may also require negotiation of franchise, right-of-way, pole attachment, and building-entry agreements—in our experience, most local governments that control many of these areas are highly motivated to facilitate the entry of new broadband providers into their communities.

Although the number of separate facets and issues definitely grows with the size of the network, they tend not to grow more than linearly with the number of sites and entities. Therefore, the larger the network implementation and the larger the user base, the less complexity there is per user—and the more optimal is the use of resources.

It is also significant that a larger "player" in the right-of-way tends to have more leverage over other entities in the right-of-way, such as other utilities, regulators, and building owners. Therefore a project that serves an entire city or region, with powerful stakeholders in government, may be better able to move roadblocks than one that will serve only a few buildings or one type of user. For example, a larger entity may be able to have a skilled and experienced group of government professionals dedicated to "expediting."

In addition to the political advantages of being a larger entity, most network construction projects have shown economies of scale for most aspects of planning, buying, and building networks (see below—Cost Factors). From a merely logistical perspective, the program manager of a large-scale project can reassign workers to other tasks if there are unexpected impediments in a particular area. In a smaller-scale project, the workers may need to stand idle, or the plan redesigned.

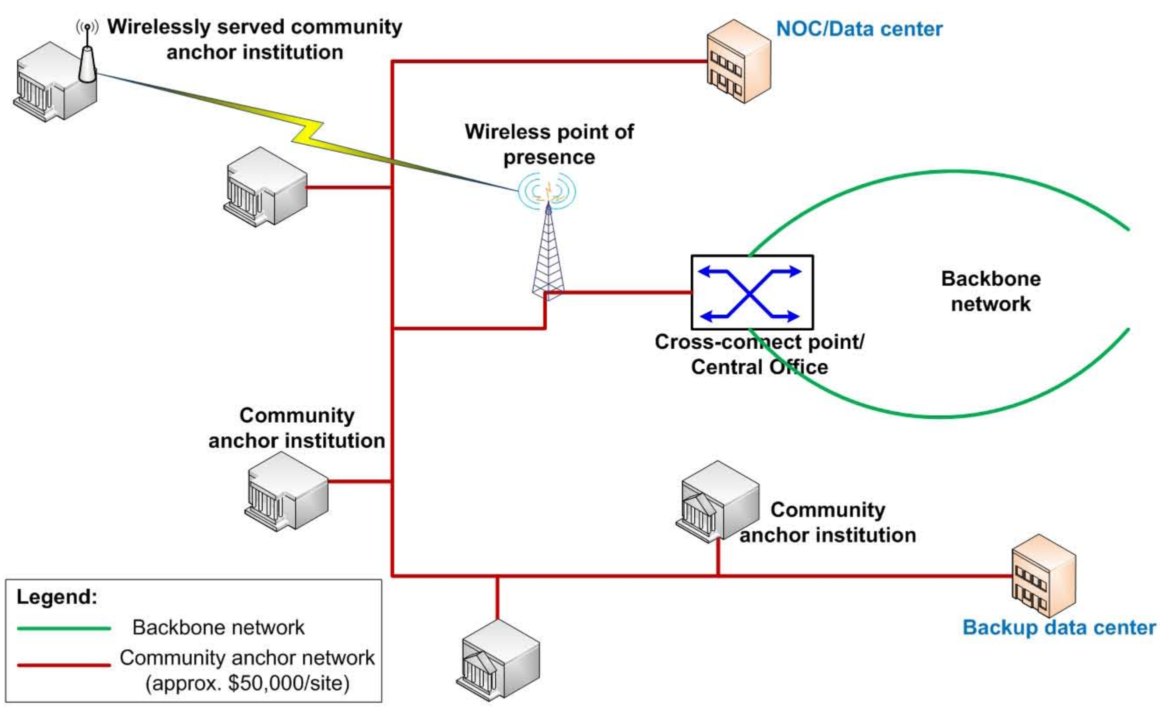
Be Flexible in Choosing Specific Technical Solutions

In almost any fiber optic construction project, there are "outlier" locations that cost significantly more than others or create exceptional risk of delay or other uncertainties. This can be because of distance, anomalous construction circumstances (obstructions, road or rail crossings, historical area, or other conflicting construction), or uncooperative building owners.

Because of these outliers, it is not unusual, in the first stage of a fiber project, to have 50 percent of the proposed construction cost assigned to serve the most costly 10 percent of the locations. It would be more beneficial to the project to cost-effectively and expeditiously serve the first 90 percent of locations, however, and serve the costly 10 percent in a second phase.

One solution is to have a "Plan B," such as a wireless system or a virtual private network, to accommodate those difficult locations, at least for a temporary period (Figure 1). Depending on the location of the locations to be served, adding a construction "Plan B" can reduce the construction cost of a network first phase by 50 percent and significantly reduce the risk of delay. It may also be possible that the extra time could be used to find other users or partners that would make fiber construction more cost effective, on a per-user basis, to the outlier locations.

Figure 1 – Community Anchor Network



Coordinate Network Intelligence with Users' Needs

Networks are growing in the features and flexibility they offer, and a cost estimate and design should incorporate the appropriate level of features and "smartness." Owning and operating the physical network and electronics, end-to-end, gives the operator wide latitude, including the ability to dedicate levels of physical and electronic redundancy to sites, have complete knowledge of the degree of network security, determine where and how to connect to the Internet and other outside networks, manage intrusion detection, and determine how quickly service will be restored if fiber is cut or other problems emerge. It also enables the operator to determine what service and capacity levels to offer and perform its own upgrades on network architecture and electronics.

Some networks operate multiple networks within each network—offering public safety grade, medical/HIPAA grade, private network, and public network security over the same physical platform. The type of service can be assigned at the port or user interface at the site. Some network operators are also combining their services with other value-added services customized to the user group, including data and server mirroring across a metropolitan area or national network, hosted virtual presence or video conferencing, turnkey telecommuting and telemedicine, national Intranet access, direct access to state and federal networks, and peering with service providers. Other networks are firmly limited to "transport only," providing only a "pipe" and perhaps Internet access, with the users responsible for any other needed features.

When the network designer and operator understand the unique needs of their users and customers, the network design can incorporate particular features, such as data centers, ring topology, options for very high capacity links, and network segmentation. When these needs are known up-front, the network operator can incorporate those features and a reasonable upgrade path, yet not require costly over-engineering. The network operator can also consider the needs of its users in subsequent generations of network electronics upgrades and reconfiguration.

The network designer must include the cost of the added network intelligence, beyond mere transport. Depending on the degree of need and architecture, the additional cost of the intelligence can be 25 percent to 100 percent beyond the cost of the construction and site electronics.

3. Cost Factors

Any planner or designer with years of experience in fiber optic projects will report a wide range of unit costs for construction. However, understanding some general factors will help understand and anticipate these costs.

Labor

Labor forms the majority of the cost of construction—approximately 50 to 80 percent. Therefore the quantity of fiber strands and cables, a materials cost, is typically a secondary consideration.

Labor costs are highly variable. Affluent areas have significantly higher labor costs in all categories, for example. And while poor economic conditions may lead construction companies to reduce their fees,[1] the companies may increase their bid rates if there is suddenly high demand for immediate construction. In general, large-scale ventures have an advantage in managing costs, because construction companies feel comfortable offering lower rates when they expect to profit from the volume and duration of a project.

Mobilization of Contractors

There is considerable time and expense in beginning construction work. Even with a completed design, the network builder must develop detailed specifications, find a potential pool of contractors, issue bid documents, review bids, select contractors, order materials, and prepare the right-of-way. The network builder will also need to go through its procurement process and legal reviews. The added expense is usually borne by the entity managing the network build—directly through the staff and engineering time, and indirectly through costs built into the rates of the building contractor.

Therefore, to the extent that it can have a single start and be managed through a single entity, a network project can minimize the time and expense spent on mobilization.

Aerial Versus Underground

Typical construction is a mixture of aerial and underground techniques, in part because aerial construction also is more vulnerable to extreme weather, particularly in wooded areas and areas with frequent ice and high winds.

In many cases, a network can be built more cheaply using aerial utility poles. This is particularly true when the poles are not crowded, and when the network builder has ownership of the utility poles (construction by power and utility companies). Best case, aerial construction can be completed for $25,000 per mile. Aerial construction may be more expensive when poles are crowded or when the utility pole owner charges high rates for access. Worst-case costs can be $100,000 per mile (which usually would lead a network owner to build underground or over another route).

Underground construction also has a wide cost range. In areas where restoration is not important and long continuous runs are possible (e.g., rural areas, in dirt, on the side of interstate roads), “plowing” the fiber into the ground is an inexpensive option—approximately $70,000 per mile. In more built-up areas, directional boring is necessary, because it is less destructive to the right-of-way and requires less restoration. Boring is more expensive, approximately $90,000 to $400,000 per mile. Boring also limits the amount of cable and conduit that can be built. (Two 2-inch conduit is a typical limit, corresponding to four medium-sized fiber optic cables.)

[1] “Strategies to Control Construction Costs: More Bang for the Stimulus Buck as Firms Clamber for Contracts,” Eric M. Weiss, the Washington Post, April 8, 2009, http://www.washingtonpost.com/wp-dyn/content/article/2009/04/07/AR2009040703828.html, accessed September 13, 2009.

Density of Sites

As noted above, unit construction costs are per mile, not per site. A high density of sites enables more sites to be reached per mile of construction. Again referring to economies of scale, if more participants can connect to a given mile of fiber, the per-site cost of a network falls substantially.

Ability to Use Existing Infrastructure

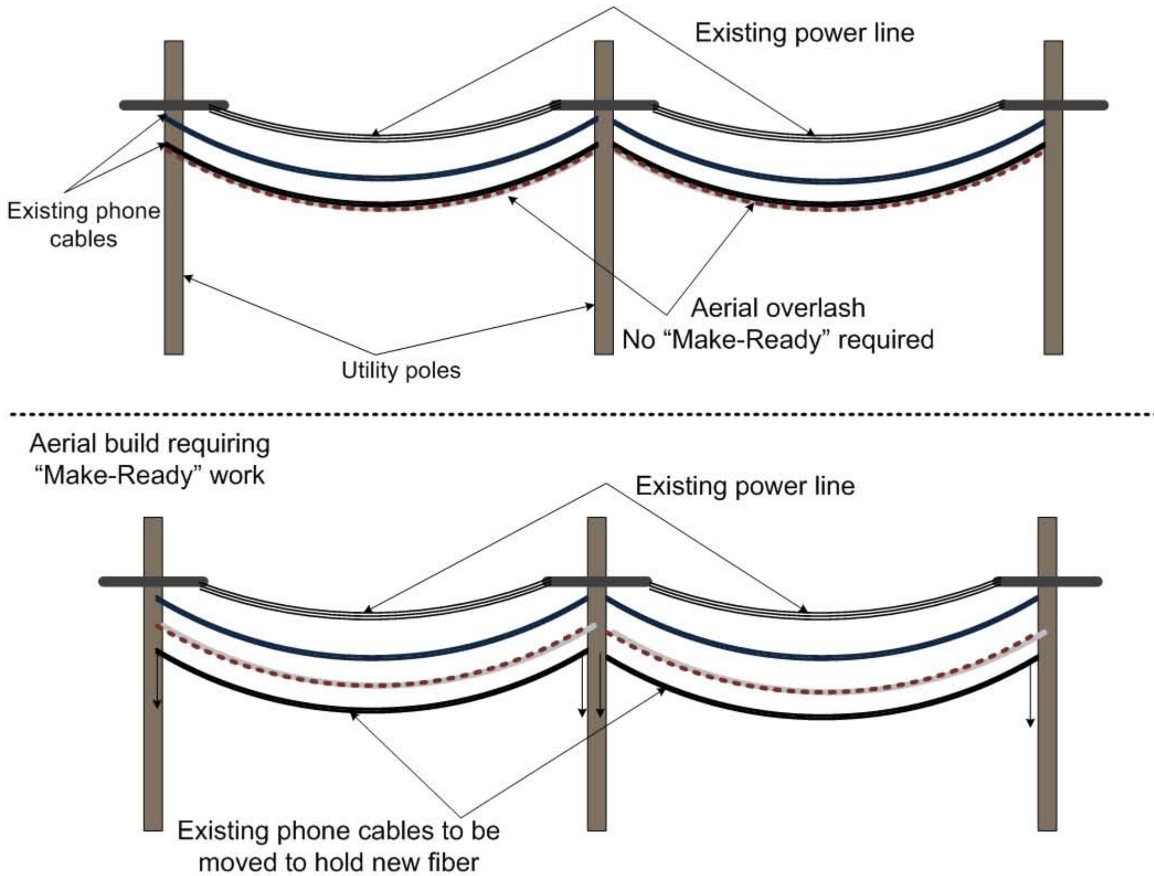
Where it is available, using existing cable infrastructure and pathways offers a range of benefits. There are a number of options for using existing cable infrastructure.

Some communications providers have excess fiber strands. Fiber count in cables ranges from 6 to 24 near residences and individual businesses to more than 1,000 on backbone routes. The cost of a 6-count fiber cable is $2,000 per mile, while an 864-count cable is $50,000 per mile, implying a marginal cost of approximately $50 per fiber per mile. Actual costs for fiber purchase or lease, of course, reflect market costs and depend on the total availability of fiber over the route–and are thus, typically, considerably higher; however, fiber lease or purchase may be a serious consideration over routes where construction is difficult or costly and considerable fiber has already been installed (e.g., river crossings, tunnels).

Utility pole attachments can be loaded with multiple fiber cables in a process called overlash. Overlashing enables a network provider to attach to utility poles without taking up more space (Figure 2). Overlashing requires the permission of the entity being attached and is limited to the loading capacity of the attachment. Some communities have the right of attachment to cable company cables on poles as part of the cable franchise agreement.

Using overlash eliminates make-ready costs and reduces construction costs to approximately $13,000 to $20,000 per mile.

Figure 2 – Overlash Construction Reduces Cost and Utilization of Utility Poles



Some entities (utilities, service providers, governments) have conduit available for purchase, lease, or trade. Pulling cables through available conduit costs $20,000 to $50,000 per mile, instead of $90,000 to $400,000 for new construction.

Redundancy and Survivability Needed

The specific requirements of the network (e.g., public safety grade, mission criticality, cost of outages) will determine the physical and electronic architecture of the network. For availability above 99 percent (fewer than eight hours of downtime per year), a building will generally need two redundant physical paths from the network to its location, along with an electronic infrastructure to accommodate failure of a fiber route or an electronic component, and backup power of sufficient duration. The network will also need to provide a 24-hour network operations center, a fiber repair crew, intrusion detection, and backup management and recovery facilities.

If network users do not require this level of availability, the network operator should determine their actual current and future requirements, and which subset of survivability and redundancy tools are needed.

Ideally, any needs for physical redundancy will be included in the initial project design. In a network designed with redundancy in mind, each portion of the network is constructed as part of a ring and economical construction is possible. In our urban case study (Section 4), the fiber cost for each site is approximately $23,000, including ring fiber construction.

On the other hand, when redundancy is constructed after the fact, it requires a custom cable pathway, usually doubling (or more) the construction cost.

4. Case Studies

Urban Case Study

One urban community designed and constructed a fiber optic network to reach community anchor and government facilities. It has the following characteristics:

- designed for public safety grade, with almost all fiber in rings;
- the right to overlash fiber to other aerial fiber optic cable in the right of way and to use existing telephone conduit, where it is available
- a citywide footprint, with no location more than ½ mile from existing fiber
- 24x7 network operations center
- On-call fiber repair staff
- In-house engineering and design
- 250 locations connected
- Typical construction costs of $8 per foot aerial and $12 per foot underground
- Individual users segmented into separate virtual private networks
- Available speeds per user from 2 Mbps to 1 Gbps
- Point-to-point services available if fiber is not cost-effective

When the community sought to expand to 220 additional community anchor sites and establish new sub-networks for secure public health and government applications, the city designed additional fiber and rings and planned to enhance its NOC. The cost to expand was estimated at $5,300,000 for the fiber optic cable (providing redundant rings to almost all users), $4,500,000 for network electronics at the new community anchor sites, and $4,900,000 for new core electronics, new network management systems and network intelligence.

On a per-site basis, the average cost for fiber was $24,000, the site electronics was $20,500, and the core electronics, management systems, and network intelligence was $22,300, for a total of approximately $67,000 per added community anchor site.

Small City Case Study

A representative small city constructed a network with:

- Fiber optic ring to key locations, single path to others
- Construction and operation by municipal power utility, which owns all utility poles and has existing underground conduit for most underground routes
- 73 mile of fiber and 84 sites
- Hub buildings inside power substations
- Services from 100 Mbps to 1 Gbps per site
- Repair and maintenance by city

The cost for fiber optic construction was $26,000 per mile for aerial, $173,000 per mile for underground, and $2,208,000 total. The cost of network electronics was approximately $1,000,000.

The average fiber cost per site was $26,300, $38,200 including electronics.

Brief Engineering Assessment: efficiencies available through simultaneous construction and co-location of communications conduit and fiber

Prepared for the City and County of San Francisco
August 2009

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1. Introduction and Summary of Conclusions

The following is a brief engineering assessment of the efficiencies available through simultaneous construction and co-location of communications conduit and fiber.

The construction of fiber optic communications cables is a costly, complex, and time consuming process. The high cost of construction is a barrier to entry for potential broadband communications providers. Available space is diminishing in the public rights of way. Cutting roads and sidewalks substantially reduces the lifetime and performance of those surfaces.

In summary, encouraging or requiring simultaneous construction and co-location of facilities in the public right of way will reduce the long-term cost of building communications facilities. This is because there are significant economies of scale through:

1. Coordination of construction with road construction and other disruptive activities in the public right of way.
2. Construction of spare conduit capacity where multiple service providers or entities may require infrastructure.

The reason that these economies are available is primarily because *fiber optic cables and installation materials alone are relatively inexpensive, often contributing to less than one quarter of the total cost of new construction.* While material costs typically fall well below $40,000 per mile (even for large cables containing hundreds of fiber strands), labor, permitting, and engineering costs commonly drive the total price towards $200,000 per mile (Table 1).

Moreover, as the ROW becomes more crowded with communications infrastructure and other utilities, the cost of new construction can grow exponentially. There are, of course, always exceptions – the benefits of collaboration tend to diminish in more rural settings. In general, however, it is in the best interests of commercial and public entities to identify construction collaboration opportunities that share the burden of expensive and duplicative labor-related costs and efficiently utilize physical space in the ROW.

If fiber construction is coordinated with a major road or utility project that is already disrupting the right of way, the incremental cost of constructing the fiber, communications conduit, and other materials ranges from $70,000 per mile to $135,000 for a single conduit. However, if fiber construction is completed as part of a separate standalone project, the cost of constructing fiber and communications conduit can range from $95,000 to $200,000 per mile.

Savings through coordination with the road or utility project can therefore range from 25% to 33%, and is greatest in crowded areas where the complexity and cost of construction is highest.

Construction of utilities or roads can provide further savings if multiple communications entities coordinate their construction and pursue a "joint trench" opportunity. In that case, multiple providers share the cost of the trenching and the design. If there are three providers in the joint trench, the cost *per entity* ranges from $55,000 to $92,000 per mile, resulting in a savings of 40% to 50% relative to construction that is not coordinated with road construction or other communications entities.

This brief report provides 1) general background on fiber optic construction and the advantages of coordination and 2) case studies explaining and detailing construction cost estimates.

2. Background

2.1 Advantage of Underground Construction

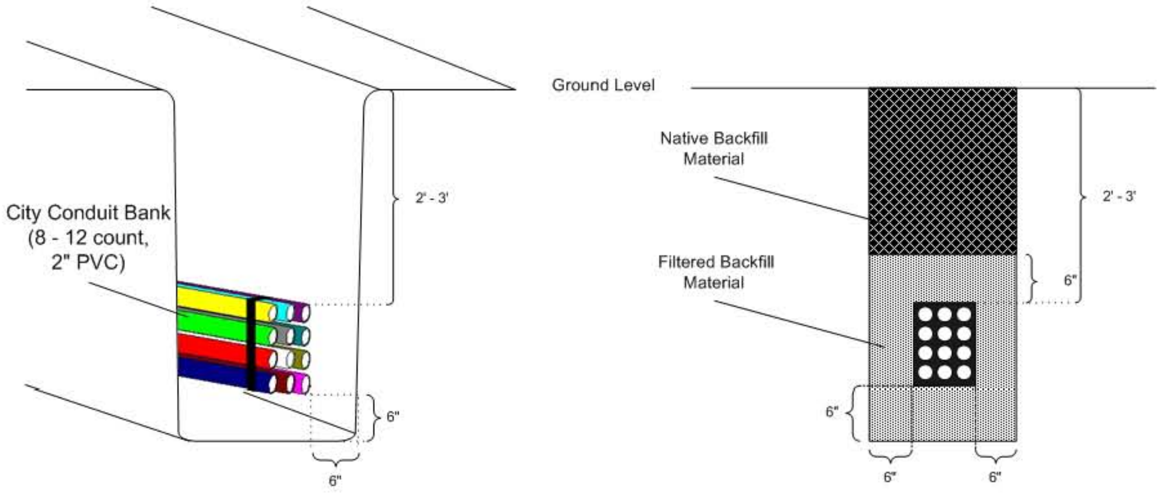
There are numerous methods for constructing fiber optic infrastructure. In particular, underground construction using protective conduits generally provides the most scalable, flexible, and durable method for developing long-term communications infrastructure, but is also typically more expensive than aerial construction methods requiring attachments to utility poles. This is because of the limit in the quantity of cables and attachments that can be placed on existing utility poles in more crowded areas, and because aerial construction is more exposed and vulnerable to outside conditions.

2.2 Advantage of Coordinated, Simultaneous Construction

Banks of conduits constructed *simultaneously* (Figure 1), or large conduits segmented with inner duct, provide multiple pathways for the installation of multiple fiber optic cables located in close proximity, with the scalability to remove, add, or replace fiber optic cables without disturbing neighboring cables.

Conversely, multiple conduits installed at different times must be physically spaced, often by several feet, to prevent damage to one while installing the next. Once the ROW becomes crowded, often the choices of construction methods are reduced, leaving only less desirable methods and more costly locations for construction of additional infrastructure.

Figure 1: Underground Conduit Bank for Multiple Users



Some of the key cost components that can be avoided or reduced through coordinated construction efforts include:

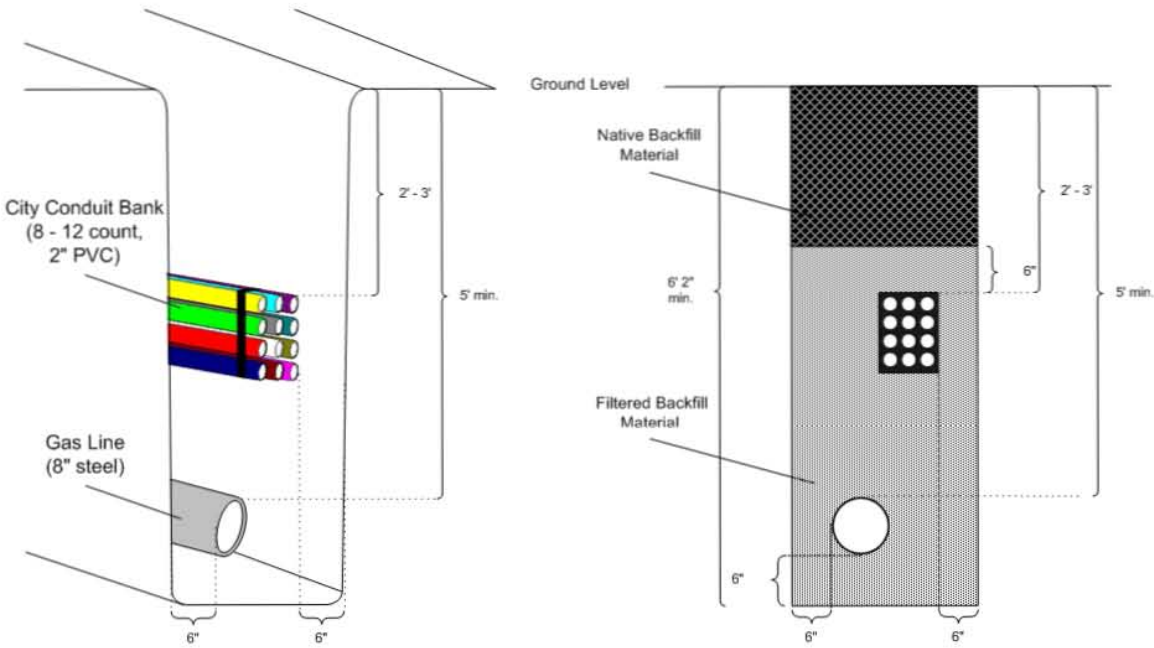
- Overall reduction in incremental labor and material costs through reduced crew mobilization expenses and through larger bulk material purchases;
- Trenching or boring costs, particularly when coordination enables lower cost methods (trenching as opposed to boring) or allows multiple entities to share a common trench or bore for their independent purposes;
- Traffic control and safety personnel, particularly when constructing along roadways requiring lane closures;
- Engineering and survey costs associated with locating existing utilities and specifying the placement location of new facilities;
- Engineering and survey costs associated with environmental impact studies and approvals;
- Lease fees for access to private easements, such as those owned by electric utilities;
- Railroad crossing permit fees and engineering;
- Restoration to the ROW or roadway, particularly in conjunction with roadway improvements; and
- Bridge crossing permit fees and engineering.

2.3 Advantage of Coordination with Other Utility Projects

Where other types of construction are occurring within or along the ROW, such as roadway widening, sidewalk repairs, bridge construction, and water or gas main installation, there is an opportunity to acquire telecommunications infrastructure at an overall reduced cost and with reduced disruption to public ROW.

Figure 2 illustrates how a multi-user conduit bank might be installed with a gas main, water main, power line, or other large utility installation requiring trenching. We note that in a case like this, it is important to ensure proper backfill of trench material and facilitate future access to both the conduit and the other utility for repair by offsetting the two utilities horizontally and requiring a somewhat wider trench. This offsets somewhat the potential cost savings by requiring a larger trench and multistep backfill process. Nonetheless, cost savings are still substantial.

Figure 2: Example Coordinated Conduit Bank and Gas Main Installation



3. Construction Case Studies with Different Degrees of Coordination

We offer the following construction scenarios reflecting real-world per-mile estimates to compare costs for incremental construction with and without collaborative opportunities in varying construction environments. For each scenario, we present a range of costs encompassing variation in labor rates and variations in the complexity of construction, from rural areas to relatively developed areas:

1. Construction of Single 2" Conduit Independent of Road Construction Project
2. Construction of Single 2" Conduit Coordinated with Road Construction Project
3. Construction of Three Separate Uncoordinated 2" Conduit Independent of Road Construction Project
4. Construction of Three Separate 2" Conduit Coordinated with Road Construction Project (Joint Trench)

3.1 Scenario 1 – Construction of Single 2" Conduit Independent of Road Construction

This example is bound by the following basic characteristics:

- 216-strand count;
- The segment is part of a backbone or a "middle mile" backbone run, as opposed to a last-mile Fiber to the Premises (FTTP) deployment targeting each home or business passed;
- Roadway crossings and a railroad crossing are required;
- Underground vaults are placed at intervals of 500-feet in areas requiring typical restoration; and
- All construction is new, using underground directional boring.

We estimate per-mile construction costs to range from approximately $95,000 to over $195,000 per mile (Table 1), or more if significant ROW space issues occur.

Table 1: Scenario 1 – Construction of Single 2” Conduit Independent of Road Construction

LABOR						
Category	**Quantity**	**Unit**	**Low Cost/Unit**	**High Cost/Unit**	**Low Cost**	**High Cost**
Design	5,280	FT.	$0.08	$0.10	$422	$528
Engineering and Permits	5,280	FT.	$0.25	$0.25	$1,320	$1,320
Railroad Crossing	1	LOT	$5,000.00	$15,000.00	$5,000	$15,000
Directional Boring for 2" Conduit	5,280	FT.	$8.00	$20.00	$42,240	$105,600
Directional Boring for 4" Conduit	0	FT.	$11.00	$25.00	$0	$0
Trenching for 24" - 36" Depth	0	FT.	$5.00	$12.00	$0	$0
Place Conduit	5,280	FT.	$1.00	$1.75	$5,280	$9,240
Place Inner Duct	0	FT.	$0.50	$1.50	$0	$0
Place Vault	11	EACH	$500.00	$750.00	$5,500	$8,250
Place Fiber in Conduit	5,280	FT.	$1.25	$2.50	$6,600	$13,200
Install Splice Enclosure	1	EACH	$300.00	$500.00	$300	$500
Splice Fiber	216	EACH	$12.00	$30.00	$2,592	$6,480
TOTAL LABOR					**$69,254**	**$160,118**
MATERIALS						
Category	**Quantity**	**Unit**	**Low Cost/Unit**	**High Cost/Unit**	**Low Cost**	**High Cost**
216 Count Fiber	6,072	FT.	$1.80	$2.50	$10,930	$15,180
Splice Kit	1	EACH	$500.00	$750.00	$500	$750
4" Conduit and Materials	0	FT.	$2.98	$3.50	$0	$0
2" Conduit and Materials	5,280	FT.	$0.88	$1.50	$4,646	$7,920
1" Inner Duct	0	FT.	$0.30	$0.45	$0	$0
Vault	11	EACH	$450.00	$600.00	$4,950	$6,600
Tax and Freight	1	LOT	$2,102.60	$3,045.00	$2,103	$3,045
TOTAL MATERIAL					**$23,129**	**$33,495**
TOTAL LABOR and MATERIALS					**$92,383**	**$193,613**

3.2 Scenario 2 – Single 2” Conduit Coordinated with Road Construction

We compare typical per-mile construction costs for constructing underground telecommunications fiber in conduit in conjunction with the installation of a road construction project. Similar savings can also result from coordination with a new utility line, such as a natural gas main or water supply main (Figure 2). We assume fiber infrastructure costs are incremental to the full costs of independent construction of the utility. This example is bound by the following basic characteristics:

- A telecommunications provider requires fiber optic cable construction over the same basic physical routing to support large fiber cables of a nominal 216-strand count;
- The segment is part of a backbone or a “middle mile” backbone run, as opposed to a last-mile Fiber to the Premises (FTTP) deployment targeting each home or business passed;

- Roadway crossings and a railroad crossing are required;
- Underground vaults are placed at intervals of 500-feet in areas requiring typical restoration; and
- All construction is new using underground trenching.

We estimate per-mile construction costs to range from approximately $70,000 per mile to over $135,000 per mile (Table 2), or more if significant ROW space issues occur.

Table 2: Scenario 2 -- Construction of Single 2" Conduit Coordinated with Road Construction Project

LABOR						
Category	**Quantity**	**Unit**	**Low Cost/Unit**	**High Cost/Unit**	**Low Cost**	**High Cost**
Design	5,280	FT.	$0.08	$0.10	$422	$528
Engineering and Permits	0	FT.	$0.25	$0.25	$0	$0
Railroad Crossing	0	LOT	$5,000.00	$15,000.00	$0	$0
Directional Boring for 2" Conduit	0	FT.	$8.00	$20.00	$0	$0
Directional Boring for 4" Conduit	0	FT.	$11.00	$25.00	$0	$0
Trenching for 24" - 36" Depth	5,280	FT.	$5.00	$12.00	$26,400	$63,360
Place Conduit	5,280	FT.	$1.00	$1.75	$5,280	$9,240
Place Inner Duct	0	FT.	$0.50	$1.50	$0	$0
Place Vault	11	EACH	$500.00	$750.00	$5,500	$8,250
Place Fiber in Conduit	5,280	FT.	$1.25	$2.50	$6,600	$13,200
Install Splice Enclosure	1	EACH	$300.00	$500.00	$300	$500
Splice Fiber	216	EACH	$12.00	$30.00	$2,592	$6,480
TOTAL LABOR					**$47,094**	**$101,558**
MATERIALS						
Category	**Quantity**	**Unit**	**Low Cost/Unit**	**High Cost/Unit**	**Low Cost**	**High Cost**
216 Count Fiber	5,280	FT.	$1.80	$2.50	$9,504	$13,200
Splice Kit	1	EACH	$500.00	$750.00	$500	$750
4" Conduit and Materials	0	FT.	$2.98	$3.50	$0	$0
2" Conduit and Materials	5,280	FT.	$0.88	$1.50	$4,646	$7,920
1" Inner Duct	0	FT.	$0.30	$45.00	$0	$0
Vault	11	EACH	$450.00	$600.00	$4,950	$6,600
Tax and Freight	1	LOT	$1,960.04	$2,847.00	$1,960	$2,847
TOTAL MATERIAL					**$21,560**	**$31,317**
TOTAL LABOR and MATERIALS					**$68,655**	**$132,875**

3.3 Scenario 3 – Three, Separate, Uncoordinated 2” Conduit Independent of Road Construction Project

We compare typical per-mile construction costs for constructing underground telecommunications fiber in three separate conduit, not coordinated with each other or with any road or utility construction projects. The cost is approximately three times the cost of Scenario One, although costs can increase even further if the first construction projects have appreciably reduced the available ROW.

This example is bound by the following basic characteristics:

- Each telecommunications provider requires fiber optic cable construction over the same basic physical routing to support large fiber cables of a nominal 216-strand count;
- The segment is part of a backbone or a “middle mile” backbone run, as opposed to a last-mile Fiber to the Premises (FTTP) deployment targeting each home or business passed;
- Roadway crossings and a railroad crossing are required;
- Underground vaults are placed at intervals of 500-feet in areas requiring typical restoration; and
- All construction is new, using directional boring.

We estimate per-mile construction costs to range from approximately $280,000 per mile to over $580,000 per mile (Table 3), or more if significant ROW space issues occur (Table 3).

Table 3: Scenario 3 -- Construction of Three Separate Uncoordinated 2” Conduit Independent of Road Construction Project

LABOR						
Category	**Quantity**	**Unit**	**Low Cost/Unit**	**High Cost/Unit**	**Low Cost**	**High Cost**
Design	15,840	FT.	$0.08	$0.10	$1,267	$1,584
Engineering and Permits	15,840	FT.	$0.25	$0.25	$3,960	$3,960
Railroad Crossing	3	LOT	$5,000.00	$15,000.00	$15,000	$45,000
Directional Boring for 2" Conduit	15,840	FT.	$8.00	$20.00	$126,720	$316,800
Directional Boring for 4" Conduit	0	FT.	$11.00	$25.00	$0	$0
Trenching for 24" - 36" Depth	0	FT.	$5.00	$12.00	$0	$0
Place Conduit	15,840	FT.	$1.00	$1.75	$15,840	$27,720
Place Inner Duct	0	FT.	$0.50	$1.50	$0	$0
Place Vault	33	EACH	$500.00	$750.00	$16,500	$24,750
Place Fiber in Conduit	15,840	FT.	$1.25	$2.50	$19,800	$39,600
Install Splice Enclosure	3	EACH	$300.00	$500.00	$900	$1,500
Splice Fiber	648	EACH	$12.00	$30.00	$7,776	$19,440
TOTAL LABOR					**$207,763**	**$480,354**
MATERIALS						
Category	**Quantity**	**Unit**	**Low Cost/Unit**	**High Cost/Unit**	**Low Cost**	**High Cost**
216 Count Fiber	18,216	FT.	$1.80	$2.50	$32,789	$45,540
Splice Kit	3	EACH	$500.00	$750.00	$1,500	$2,250
4" Conduit and Materials	0	FT.	$2.98	$3.50	$0	$0
2" Conduit and Materials	15,840	FT.	$0.88	$1.50	$13,939	$23,760
1" Inner Duct	0	FT.	$0.30	$0.45	$0	$0
Vault	33	EACH	$450.00	$600.00	$14,850	$19,800
Tax and Freight	1	LOT	$6,307.80	$9,135.00	$6,308	$9,135
TOTAL MATERIAL					**$69,386**	**$100,485**
TOTAL LABOR and MATERIALS					**$277,149**	**$580,839**
TOTAL COST per USER					**$92,383**	**$193,613**

3.4 Scenario 4 – Three Separate 2” Conduit Coordinated with Road Construction Project (Joint Trench)

We compare typical per-mile construction costs for constructing underground telecommunications fiber in three separate conduit, coordinated with a road or utility construction project in a joint trench.

This example is bound by the following basic characteristics:

- Each telecommunications provider requires fiber optic cable construction over the same basic physical routing to support large fiber cables of a nominal 216-strand count;
- The segments are part of a backbone or a “middle mile” backbone run,

as opposed to a last-mile Fiber to the Premises (FTTP) deployment targeting each home or business passed;

- Roadway crossings and a railroad crossing are required;
- Underground vaults are placed at intervals of 500-feet in areas requiring typical restoration; and
- All construction is new, using underground trenching.

We estimate per-mile construction costs to range from approximately $160,000 per mile to over $280,000 per mile (Table 3), or more if significant ROW space issues occur.

The per mile costs of any of the above scenarios can be compared with the incremental cost attributed to each owner of the communications infrastructure, illustrating the most significant cost savings compared to other construction coordination opportunities. We estimate per-mile construction costs to be approximately $55,000 per entity (or conduit), or a total of over $95,000 per mile (Table 4), leveraging open trench. In this scenario, per mile costs would be the approximately same per entity regardless of the number of collaborative partners (or conduits) over a fairly wide range, since a large trench is necessary for the utility installation providing the coordination opportunity.

Table 4: Scenario 4 -- Construction of Three Separate 2" Conduit Coordinated with Road Construction Project (Joint Trench)

LABOR						
Category	**Quantity**	**Unit**	**Low Cost/Unit**	**High Cost/Unit**	**Low Cost**	**High Cost**
Design	5,280	FT.	$0.08	$0.10	$422	$528
Engineering and Permits	0	FT.	$0.25	$0.25	$0	$0
Railroad Crossing	0	LOT	$5,000.00	$15,000.00	$0	$0
Directional Boring for 2" Conduit	0	FT.	$8.00	$20.00	$0	$0
Directional Boring for 4" Conduit	0	FT.	$11.00	$25.00	$0	$0
Trenching for 24" - 36" Depth	5,280	FT.	$5.00	$12.00	$26,400	$63,360
Place Conduit	15,840	FT.	$1.00	$1.75	$15,840	$27,720
Place Inner Duct	0	FT.	$0.50	$1.50	$0	$0
Place Vault	33	EACH	$500.00	$750.00	$16,500	$24,750
Place Fiber in Conduit	15,840	FT.	$1.25	$2.50	$19,800	$39,600
Install Splice Enclosure	3	EACH	$300.00	$500.00	$900	$1,500
Splice Fiber	648	EACH	$12.00	$30.00	$7,776	$19,440
TOTAL LABOR					**$87,638**	**$176,898**
MATERIALS						
Category	**Quantity**	**Unit**	**Low Cost/Unit**	**High Cost/Unit**	**Low Cost**	**High Cost**
216 Count Fiber	18,216	FT.	$1.80	$2.50	$32,789	$45,540
Splice Kit	3	EACH	$500.00	$750.00	$1,500	$2,250
4" Conduit and Materials	0	FT.	$2.98	$3.50	$0	$0
2" Conduit and Materials	15,840	FT.	$0.88	$1.50	$13,939	$23,760
1" Inner Duct	0	FT.	$0.30	$45.00	$0	$0
Vault	33	EACH	$450.00	$600.00	$14,850	$19,800
Tax and Freight	1	LOT	$6,307.80	$9,135.00	$6,308	$9,135
TOTAL MATERIAL					**$69,386**	**$100,485**
TOTAL LABOR and MATERIALS					**$157,024**	**$277,383**
TOTAL COST per USER					**$52,341**	**$92,461**

Of course, a nearly infinite number of possible scenarios and cost models can be presented, but in most cases, clear construction cost savings can be realized on the whole through collaborative efforts in the right of way. These scenarios do not consider non-engineering matters, such as conduit ownership, license agreements, and the impact that low-cost, competitive access to conduit might have on the business cases for constructing fiber, whether positive or negative, for different entities.